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Design of a Performance Measurement Framework for the Sudanese Construction Contractor's Organizations

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Abstract: This paper investigates the relations between the Sudanese construction contractor's and other related institutions "resources" in term of project management capabilities, strategic decisions, strength of relationships with other parties and external factors, construction project performance and contractor's organization performance from a resource based perspective. A structural equation (SEM) model was set to measure the seven latent variables through their constituent variables. Based on the findings of this study, it can be concluded that, the paper introduced a new method to measure performance in both qualitative and the quantitative terms.

Keywords: *Project performance; Performance measurement; Structural equation model*.

1. INTRODUCTION

Performance measurement is a significant management tool that organizations use to compete in an ever changing environment. It supports decision-making processes by providing information about how well a set of targets has been met and how precisely predictions have been made [1].

Sink and Tuttle asserted that what cannot be measured cannot be managed. Therefore, one of the key tasks of organizations is to design and implement an effective measurement system that assist in providing sufficient and detailed information about their performance for internal and external purposes [2].

Organizations use performance measures to evaluate, control and develop business processes to achieve their objectives [3]. Another reason for using performance measures is benchmarking purposes [3] where the performance of organizations within one sector can be compared, this may include comparing, evaluating and analyzing performance of different departments within one organization are compared, analyzed and evaluated [4]. According to Neely et al. [5] reasons for using performance measurement can be classified into one of the following categories: checking the organization's position, communicating the organization's position, confirming the organization's priorities or compelling progress. While Sousa et al. [6] identified the main reason for undertaking this exercise, driving the performance in the direction of achieving organization objectives. Performance measurement also helps in demonstrating transparency, promoting a productive environment and shaping accountability [7]. Frameworks include a set of performance measures, guidance and recommendations on the way they are used and the areas they need to focus on in order to help organizations measure their performance.

The main aim of the construction industry is to produce buildings and infrastructure using projects as vehicles. Consequently, the performance of construction projects has been carried out using two approaches. The first approach focused on the finished product and the second approach focused on the creation of the product as a process [8]. The first approach, which considers completing the project on time within budget and predetermined specifications as the criteria for project success, has been the predominant approached in measuring the performance of construction projects [8]. In this approach, the performance of construction projects is judged by using the same criteria used to evaluate the success of project. The three criteria represented the contractor's perspective of construction project success [9]. Kagioglou et al. [8] believe that although the three criteria can be considered as an indication of project success or failure, using them exclusively does not show a sufficiently comprehensive view of project performance.

The macro perspective of project success is accordingly formed in the conceptual and operational phases of projects. The micro view, on the other hand, focuses on specific project achievements. These achievements are usually assessed at the end of construction phase by the parties involved in the project. Hence, the micro perspective of project success is formed in the construction phase and includes success criteria such as time, cost and quality [10]. Kometa et al. [11] expanded the way project success is evaluated by using a comprehensive framework. Their criteria comprised safety, economy, time and flexibility to users. Kumaraswamy and Thorpe [12] in the same way proposed a range of criteria for evaluating projects. These included cost, time, and quality of workmanship, client and project manager's satisfaction, transfer of technology, friendliness of environment, health and safety. Success criteria are characteristics, features or principles against which project performance is measured and judgments are then made. A success dimension, on the other hand, is a set of success criteria that have common attributes that used to describe specific aspect of project performance. The construction industry used measurement frameworks to measure project performance. In this regard, Bassioni et al. [13] pointed out that the use of performance measurement framework (such as the European Foundation for Quality Management (EFQM) excellence model, key performance indicators (KPI) and the Balanced Scorecard (BSC) in construction industry are rising in an attempt to improve performance.

The main objective of this study is to design a comprehensive performance measurement system which will have the ability to assess the performance at both project and organization level. This model helps organizations to be aware of their performance and decide on long-term strategies accordingly. The study population consisted of all construction contractors' organizations registered in Sudanese Contractor Association (SCA) and the Organizing Council for Engineering Works Contractors (OCEWC).

2. MATERIALS AND METHODS

A questionnaire survey was used to elicit the attitudes of contractors towards the factors affecting the performance of construction projects and organizations in the Sudanese context. The target populations of contractors were those registered at the Sudanese Contractors Association and the Organizing Council of Engineering Works Contractors. One hundred and fourteen questionnaires were distributed to contractors. Ninety three questionnaires were returned (response rate of 82.1%).The questionnaire has been validated by the criterion-related reliability test which measures the correlation coefficient between the factors affecting the performance of construction projects and structure validity test. The respondents were experienced construction project managers and organizations managers. Forty two factors believed to affect project and organization performance were considered in this study and were listed under seven groups based on the literature reviewed. The performance factors were summarized and collected according to previous studies as recommended by local experts. The main variables considered in this paper are: resources, project management capabilities, strength of relationships with other parties, strategic decisions, external factors, project performance, and organization performance. Computer software for structural equation modeling (SEM) analysis called EQS 6.2 was used in the process of data analysis.

3. RESULTS AND DISCUSSION

3.1 Validity of the Performance Measures and Indicators

The data obtained from the 93 construction organizations and 325 projects were analyzed by using Structural equation modeling (SEM), which is superior to other methods since it combines a measurement model (confirmatory factor analysis) and a structural model (regression or path analysis). It recognizes the measurement error, and offers an alternate method for measuring prime variables of interest through the inclusions of latent and surrogate variables. SEM is also referred to as causal modeling, causal analysis, simultaneous equation modeling, and analysis of covariance structures, path analysis, or confirmatory factor analysis [14]. In this part of the paper, after testing the validity of the measurement model, the analysis results of the structural model will be presented.

3.1.1 Content Validity Testing of Performance Measures

Content validity tests rate the extent to which a constituent variable belongs to its corresponding construct. Since content validity cannot be tested by using statistical tools, an in-depth literature survey is necessary to keep the researcher's judgment on the right track [15]. An extensive literature survey was conducted to specify the variables that define latent variables.

3.1.2. Scale Reliability Testing of Performance Measures

Scale reliability is the internal consistency of a latent variable and is measured most commonly with a coefficient called Cronbach's alpha. The purpose of testing the reliability of a construct is to understand how each observed indicator represents its correspondent latent variable. According to EQS 6.2 analysis results, Cronbach's alpha values as shown in Table (1). These reliability values are satisfactory since the Cronbach's alpha coefficients are all above 0.70

3.1.3 Convergent Validity Testing of Performance Measures

Convergent validity is the extent to which the latent variable correlates to corresponding items designed to measure the same variable. Ideally, convergent validity is tested by determining whether the items in a scale converge or are loaded together in a single construct. Dunn et al. [15] state that if the factor loadings are statistically significant, then convergent validity exists. Since the sample size and statistical power have a substantial effect on the significance test, this statement needs expanding. To assess convergent validity, the researcher should also assess the overall fit of the measurement model, the magnitude, direction, and statistical significance of the estimated parameters between latent variables and their indicators. The model parameters were assessed and all factor loadings were found to be significant at $\alpha = 0.05$.

Table 1. Cronbach's alpha values for latent variables

Latent variable	Cronbach's alpha values
Resources	0.943
Project management capabilities	0.787
External factors	0.923
Strategic decisions	0.927
Strength of relationships with other parties	0.852
Projects performance	0.716
Organization performance	0.846

3.1.4 Discriminant Validity Testing of Performance Measures

The discriminant validity is the extent to which the items representing a latent variable discriminate that construct from items representing other latent variables. Low correlations between variables indicate the presence of discriminant validity. The correlation metrics calculated for all constructs shows that all intercorrelations are below 0.90, suggesting that there is no multicollinearity [16]. However, it indicates that the constructs have discriminant validity, which correlations provide evidence that is complementary.

3.2 Structural Model Analysis

Steps of Structural Equation Modeling:

- Specification of the model,
- Estimation and identification of the model,
- Evaluation of the model fit.

3.2.1 Specification of the Proposed Model

This model is specified by the following direct path equations:

Organization performance = $\boldsymbol{\mu}1$*Project performance + $\boldsymbol{\mu}2$*Resources + $\boldsymbol{\mu}3$*Strategic decisions + $\boldsymbol{\alpha}1$ (1)

Project performance = $\boldsymbol{\mu}4$* Resources + $\boldsymbol{\alpha}2$ (2)

Strategic decisions = $\boldsymbol{\mu}5$* Project management capabilities + $\boldsymbol{\alpha}3$ (3)

Resources = $\boldsymbol{\mu}6$* Strategic decisions + $\boldsymbol{\mu}7$* Project management capabilities + $\boldsymbol{\alpha}4$ (4)

Strength of relationship with other parties = $\boldsymbol{\mu}8$* External factors + $\boldsymbol{\alpha}5$ (5)

Project management capabilities = $\boldsymbol{\mu}9$* External factors + $\boldsymbol{\alpha}6$ (6)

where ; $\boldsymbol{\mu}$ is a path coefficient, and $\boldsymbol{\alpha}$ is an error term.

3.2.2 Estimation and Identification of the Proposed Model

There are several methods of model estimation. Some frequently employed methods include maximum likelihood (ML), generalized least squares (GLS), asymptotically distribution free (ADF) estimator, and robust statistics. The robust model fits indices such as the non-normed fit index (NNFI), the comparative fit index (CFI), the root mean square error of approximation (RMSEA) and the ratio of Chi square ($\chi2$) per degree of freedom are provided in the analysis report.

3.2.3 Evaluation of the Model Fit

It means to determine how well the model as a whole explains the data. Once it is determined that the fit of a structural equation model to the data is adequate, the performance measurement model is completed. It seems that the concern for overall model fit is sometimes so great that little attention is paid to whether the estimates of its parameters are actually meaningful. According to the analysis of the model fit indices for the constructs of the model, it is found that all variables fit to its latent variable well beyond the recommended values. Reliability values of the constructs were also calculated and presented in the previous parts of the analysis. Having obtained reliable constructs and constituent variables with significant factor loadings and goodness of fit indices within the allowable ranges for each construct, the structural model will be assessed below in Fig.1.The overall model fit indices listed in Table 2 suggested that a relatively good fit of the data since all findings were within the allowable ranges. In Fig. 1, the path coefficients marked on the arrows can be interpreted as being similar to the regression coefficients that describe the linear relationship between two latent variables [17].

Although, model fit indices of the structural model were within the allowable ranges, it was observed that one of the path coefficients was not significant at α=0.05. Moreover, the insignificant path coefficient was found to be between the constructs, "project performance" and "organization performance" which is considered as a significant relationship both in theory and practice.

Nevertheless, this finding required the investigation of different relationships between the constructs of the model. Perhaps more often, researchers' initial models do not fit the data very well. When this happens, the model should be respecified. Hence, the model was respecified and the fit of the model was reevaluated. An equivalent respecified model explains the data just as well as the researcher's preferred model to did, but with a different configuration of the hypothesized relations.

Table 2. Model fit indices for initial model

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.727
CFI	0 (no fit)-1 (perfect fit)	0.742
RMSEA	< 0.1	0.082
$\chi2$/ dof	< 3	1.500

Table 3. Model fit indices for "respecified model"

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.787
CFI	0 (no fit)-1 (perfect fit)	0.783
RMSEA	< 0.1	0.082
$\chi2$/ dof	< 3	1.500

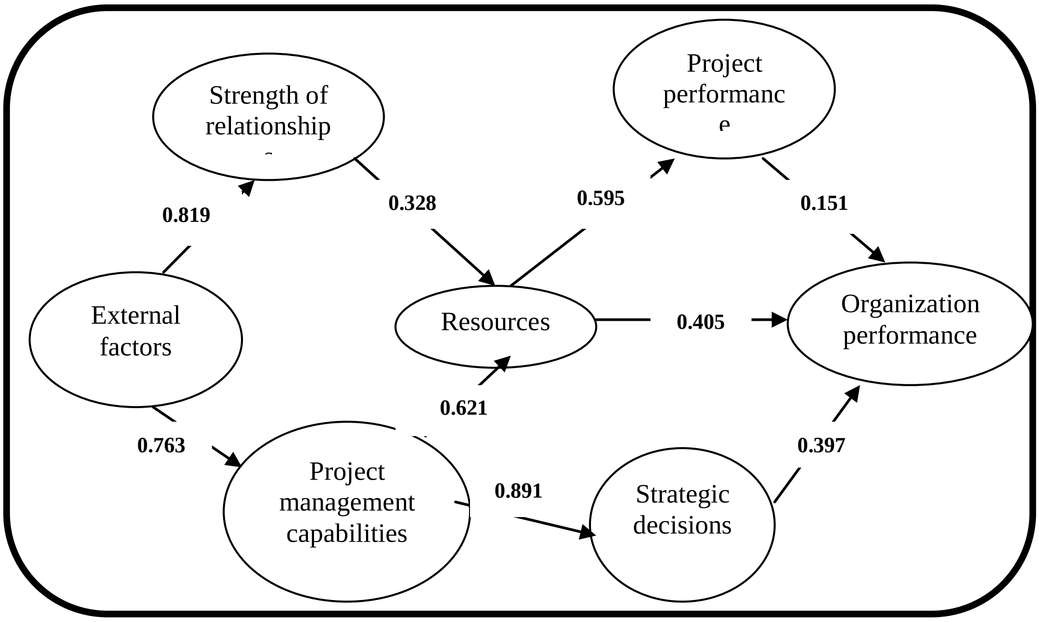

Fig. 1. The initial (proposed) model

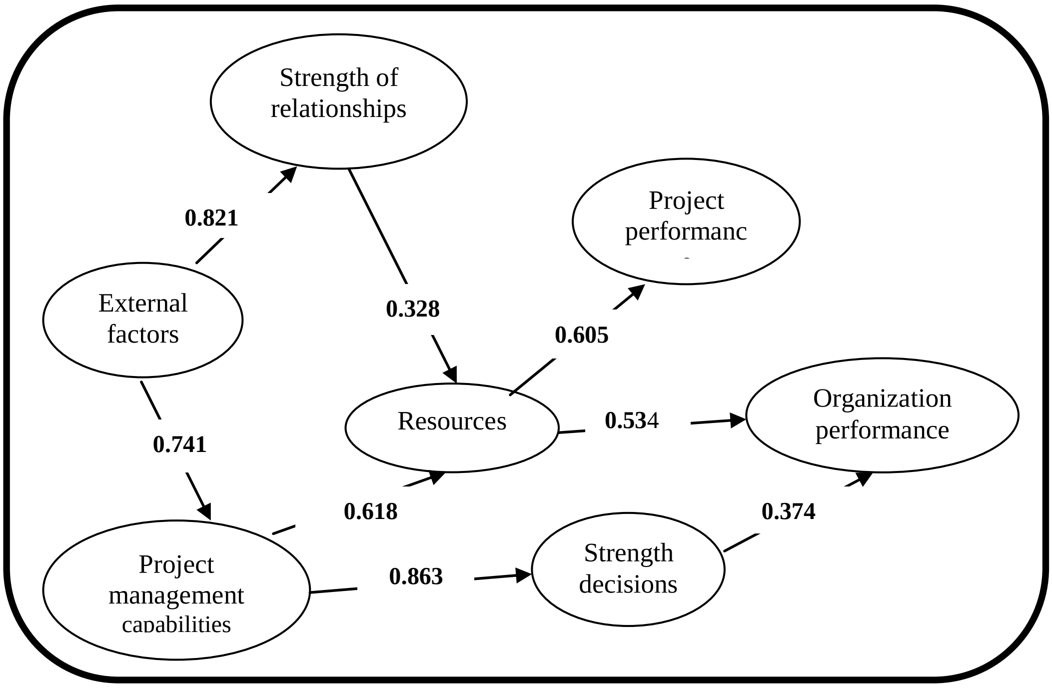

Fig. 2. The respecified model

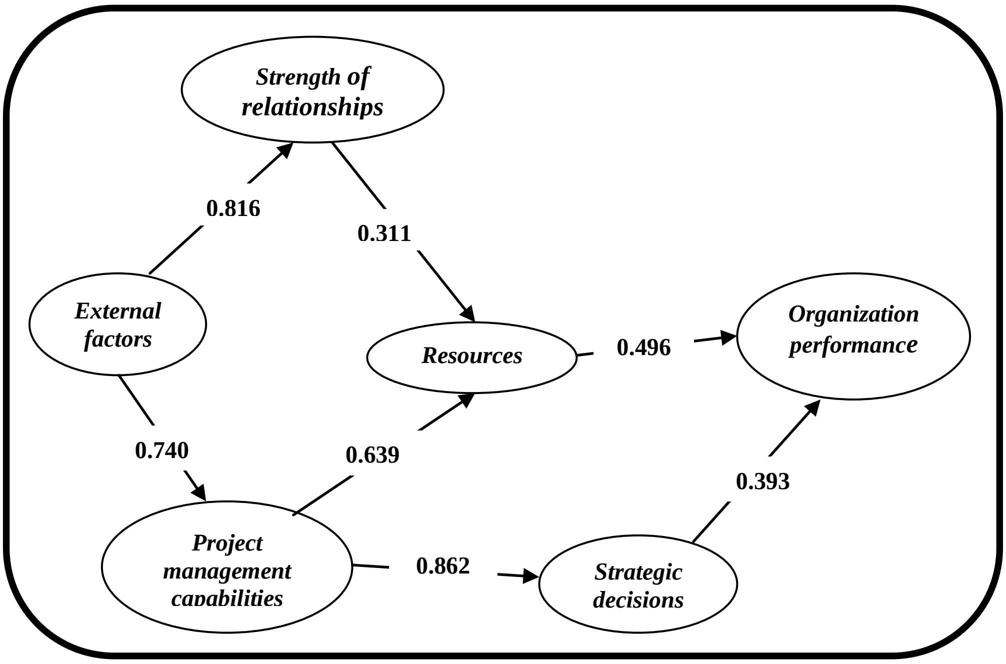

Fig. 3. The final model

Table 4. Model fit indices for "final model"

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.868
CFI	0 (no fit)-1 (perfect fit)	0.860
RMSEA	< 0.1	0.067
χ2/ dof	< 3	1.480

An equivalent model thus offers a competing account of the data. For a given structural equation model, there may be many, and in some cases infinitely equivalent variations. Thus, it is necessary for the researcher to explain why the preferred model should not be rejected in favor of statistically equivalent ones. In the respecified model, an insignificant path coefficient between "project performance" and "organization performance" constructs was eliminated (Fig. 2). However, as mentioned before, the link between the "project performance" and the "organization performance" is inevitable. Thus, it was decided to consider this strong relationship in an additional structural model later.

4. CONCLUSIONS

Finally, three models were obtained with have the ability to measure performance from different perspectives. In the first model, effects of determined measures of performance were shown on both projects and organization performance which makes it a single tool to measure project performance and organization performance in a one measurement model (Fig. 1).

In the second model, neglecting the effects of performance measures on projects performance, their effects on organization performance only were considered (Fig. 2). In the last and the final partial model, the effects of projects performance on organization performance were investigated (Fig. 3).

This well-known relationship was evaluated from the measures of projects performance to the indicators of organization performance which were taken as perspectives of balanced scorecard. The effects of each variable on perspective of organization performance were demonstrated in mathematical equations. Goodness of fit indices for all of the three models was found to be quite satisfactory as shown in Tables 2, 3 and 4.

Acquisition of the three different models with valid variables and significant paths was found to potential to be used in the construction industry in order to measure the performance of construction organizations and projects.

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APPENDIX

Questionnaire for the Sudanese construction contractor's organizations

- Check the most appropriate × for multiple choice questions.
- Questions will be answered in a **1** to **5** Likert Scale.
- 1: Very low, 2: Low, 3: Average, 4: High & 5: Very high.

"All information given by the **Organizations** will be kept confidential and used for academic issues only. Thereof, within the context of the questionnaire, names were not asked".

1. General Information

General Information	Answer			
Number of years in construction market?	1-5	5-10	More than 10 yrs.	
Organization experience	Building	Roads	Water	Others
Is the organization work outside Sudan?	Yeas		No	
Organization capital in million SDG	0-1	1-5	5-6	More than 10

2. Resources

Resources	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Financial resources										
Technical competency										
Leadership										
Experience										
Organization image										
Infrastructure										
Human resources										

3. Project Management Capabilities

Project Management Capabilities	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Human resources management										
Cost management										

Quality management										
Schedule management										
Risk management										
Supply chain management										
Health & safety management										
Knowledge management										
R & D management										

4. Strength of Relationships with other Parties

Strength of Relationships with other Parties	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Relation with government										
Relations with labor organizations										
Relations with competitors										
Relations with community organizations										

5. Strategic Decisions

Strategic Decisions	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Differentiation strategy										
Project selection strategies										
Market selection strategies										
Partner selection strategies										
Organization management strategies										
Customer relations strategies										

6. External Factors

External Factors	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
International relations										
Macroeconomics factors										
Political factors										
Socio cultural factors										
Legal factors										
Suppliers power										
demand										
Technology										
Market competitions										

7. Project Performance

Project Performance	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Project profitability										
Internal customer satisfaction										
External customer satisfaction										

8. Organization Performance

Organization Performance	Impact					Performance level				
	1	2	3	4	5	1	2	3	4	5
Financial perspective										
Learning and growth perspective										
Internal business perspective										
Customer perspective										